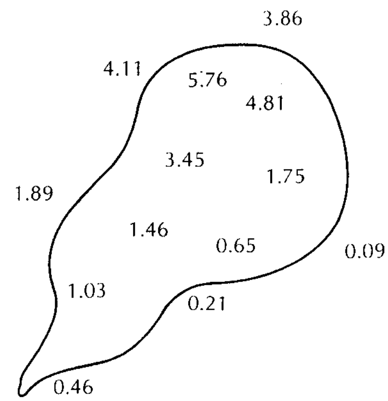


FIGURE 2.5 Precipitation-gage network over a drainage basin. Precipitation amounts are given in inches. Station locations are at decimal points.

precipitation contour map with lines of equal rainfall **(isohyets).** In drawing the isohyets, such factors as known influence of topography on precipitation can be taken into account. Simple linear interpolation between precipitation stations can also be used. The area bounded by adjacent isohyets is measured with a planimeter, and the average depth of precipitation over the area is the mean of the bounding isohyets. The effective uniform depth of precipitation is the weighted average based on the relative size of each isohyetal area (Figure 2.6). The drawback of the isohyetal method is that the isohyets must be redrawn and the areas remeasured for each analysis.

The **Thiessen method** to adjust for nonuniform gage distribution uses a weighing factor for each rain gage. The factor is based on the size of the area

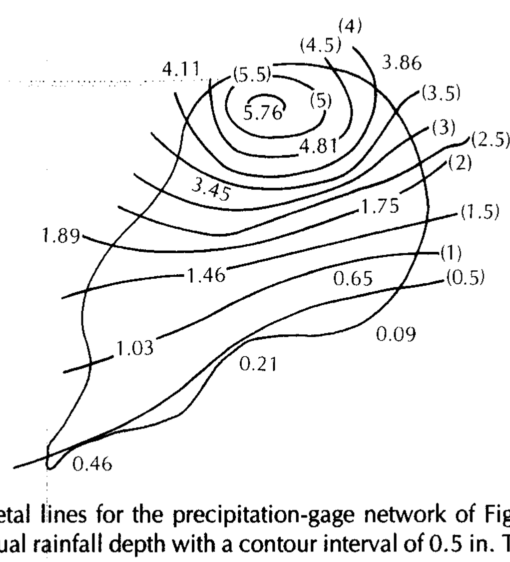


FIGURE 2.6 Isohyetal lines for the precipitation-gage network of Figure 2.5. The isohyets show contours of equal rainfall depth with a contour interval of 0.5 in. The contours are based on simple linear interpolation.

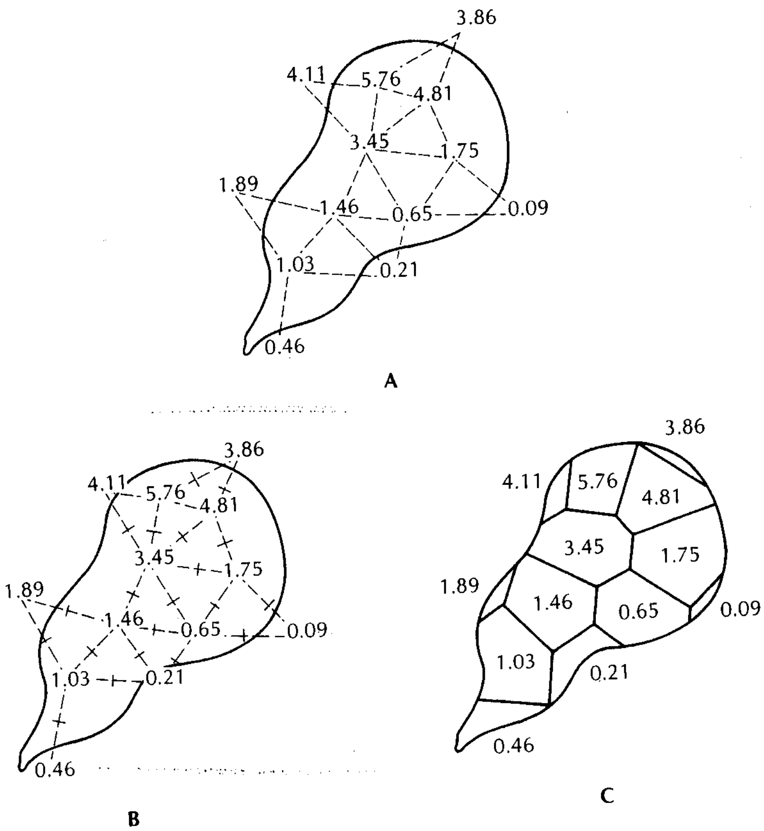


FIGURE 2.7 Thiessen polygons based on the rain-gage network of Figure 2.5. **A.** The stations are connected with lines. **B.** The perpendicular bisector of each line is found. **C.** The bisectors are extended to form the polygons around each station.

within the drainage basin that is closest to a given rain gage. These areas are irregular polygons. The method of constructing them can be described rather easily; however, it takes a bit of practice to master the technique. The rain-gage network is drawn on a map of the drainage basin. Adjacent stations are connected by a network of lines (Figure 2.7A). Should there be doubt as to which stations to connect, lines should be between the closest stations. A perpendicular line is then drawn at the midpoint of each line connecting two stations (Figure 2.7B), and extensions of the perpendicular bisectors are used to draw polygons around each station (Figure 2.7C). It is best to start with a centrally located station and then expand the polygonal network outward. The area of each polygon is measured, and a weighted average for each station's precipitation is used to find the EUD.

In mountainous areas, orographic effects can create vastly different microclimates over small distances. Significant precipitation can fall on one side of a ridge but little on the other. In such regions the Thiessen method and contouring by linear interpolation can yield erroneous results. Detailed study of the vegetation can identify wet and dry slopes. This information, in conjunction with topographic maps, can be used to make interpreted contour maps with isohyetal lines reflecting the presence of wet and dry slopes.

EXAMPLE PROBLEM Determine the effective uniform depth of precipitation using the arithmetic mean, isohyetal, and Thiessen methods.

Arithmetic Mean Method

Figure 2.5 shows a drainage basin with seven stations in its boundaries. An additional six stations are located outside the drainage divide. In the arithmetic mean method, only the gages inside the drainage basin boundary are considered.

$$\text{Arithmetic mean} = \frac{1.03 + 0.65 + 1.46 + 1.75 + 4.81 + 3.45 + 5.76}{7} = 2.70 \text{ in.}$$

Isohyetal Method

The first step is to draw lines of equal precipitation (isohyets) on the drainage basin map. Isohyets are usually whole numbers or decimals (every 0.1 in., every 0.5 in., every 1 mm, etc.). The following rules apply:

1. Isohyets never cross.
2. Isohyets never split.
3. Isohyets never meet.
4. A station that does not fall on an isohyet will be between two isohyets. The isohyets will both be equal (either larger or smaller than the station value) or one will be larger and one smaller.
5. Adjacent isohyets must be equal or only one contour interval different in value.
6. Isohyets should be scaled between stations using linear interpolation.

Figure 2.6 shows the isohyetal map of the problem area.

The area between adjacent isohyets is determined by use of a planimeter. The equivalent uniform depth of precipitation between isohyets is usually assumed to be equal to the median value of the two isohyets. For example, the EUD between a 1-in. isohyet and a 2-in. isohyet is 1.5 in. For areas enclosed by a single isohyet, judgment should be used to estimate the equivalent uniform depth. The weighted average precipitation is based on the equivalent uniform depth of precipitation between adjacent isohyets and their areas.

A Isohyet (in.)	*B* Estimated EUD	*C* Net Area (sq mi)	*D* Percent of Total Area	*E* Weighted Precipitation (in.) (*B* × *D*)
5.5+	5.6	1.1	0.8	0.045
5.0–5.5	5.25	7.6	5.3	0.278
4.5–5.0	4.75	10.6	7.4	0.352
4.0–4.5	4.25	9.5	6.7	0.285
3.5–4.0	3.75	8.6	6.0	0.225
3.0–3.5	3.25	8.3	5.8	0.189
2.5–3.0	2.75	10.7	7.5	0.206
2.0–2.5	2.25	12.3	8.6	0.194
1.5–2.0	1.75	15.1	10.6	0.186
1.0–1.5	1.25	23.8	16.7	0.209
0.5–1.0	0.75	31.2	21.8	0.164
<0.5	0.3	4.0	2.8	0.008
TOTAL		142.8 sq mi		2.34 in. NET EUD

Thiessen Method

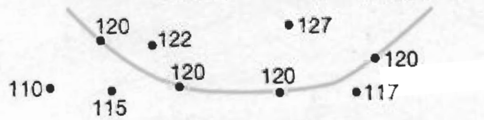
The Thiessen method provides for the nonuniform distribution of gages by determining a weighting factor for each gage. A weighted mean of the precipitation values can then be computed. Thiessen polygons for the example problem are shown in Figure 2.7C. The area of each polygon is determined by a planimeter.

A Station Precipitation (in.)	*B* Net Area (sq mi)	*C* Percent of Total Area	*D* Weighted Precipitation (in.) (*A* × *C*)
5.76	16.9	11.9	0.686
4.81	16.1	11.4	0.546
4.11	3.4	2.4	0.099
3.86	1.6	1.1	0.044
3.45	19.3	13.6	0.470
1.89	2.5	1.8	0.033
1.75	12.0	8.5	0.148
1.46	19.8	14.0	0.204
1.03	18.0	12.7	0.131
0.65	17.0	12.0	0.078
0.46	6.0	4.2	0.019
0.21	7.2	5.1	0.011
0.09	2.0	1.4	0.001
TOTAL	141.8 sq mi		2.47 in. NET EUD

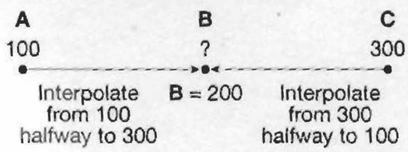
A weighted mean of the EUD is found, based on the depth of precipitation and the area of the polygon within the basin boundary.

RULES FOR CONTOUR LINES

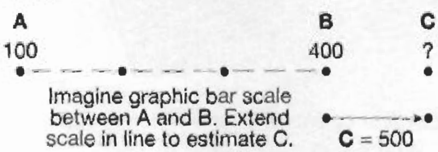
1. Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation. The contour lines are constructed by surveying the elevation of points, then connecting points of equal elevation.



2. Interpolation is used to estimate the elevation of a point B located in line between points A and C of known elevation. To estimate the elevation of point B:



3. Extrapolation is used to estimate the elevations of a point C located in line beyond points A and B of known elevation. To estimate the elevation of point C, use the distance between A and B as a ruler or graphic bar scale to estimate in line to elevation C.

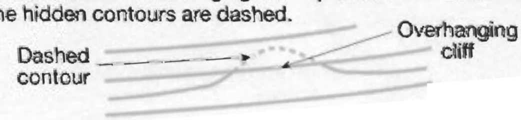


4. Contour lines always separate points of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction on the map is higher and which is lower, relative to the contour line in question, by checking adjacent elevations.

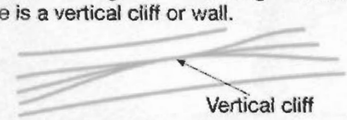
5. Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.

6. The elevation between any two adjacent contour lines of different elevation on a topographic map is the *contour interval*. Often every fifth contour line is heavier so that you can count by five times the contour interval. These heavier contour lines are known as *index contours*, because they generally have elevations printed on them.

7. Contour lines never cross each other except for one rare case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.

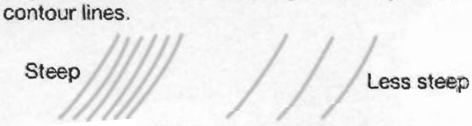


8. Contour lines can merge to form a single contour line only where there is a vertical cliff or wall.

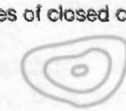


9. Evenly spaced contour lines of different elevation represent a uniform slope.

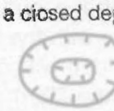
10. The closer the contour lines are to each other the steeper the slope. In other words, the steeper the slope the closer the contour lines.



11. A concentric series of closed contours represents a hill:

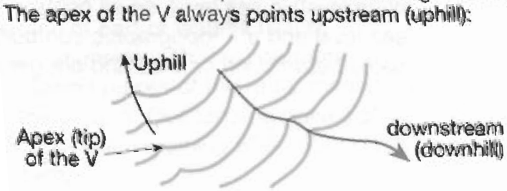


12. *Depression contours* have hachure marks on the downhill side and represent a closed depression:



See Figure 9.8

13. Contour lines form a V pattern when crossing streams. The apex of the V always points upstream (uphill):



14. Contour lines that occur on opposite sides of a valley or ridge always occur in pairs. See Figure 9.9.

FIGURE 9.6 Rules for constructing and interpreting contour lines on topographic maps.